

## BACKGROUND

The long-term objective of the U.S. AMLR field research program is to describe the functional relationships between Antarctic krill (*Euphausia superba*), their predators, and key environmental variables. The field program is based on two working hypotheses: (1) krill predators respond to changes in the availability of their food source; and (2) the distribution of krill is affected by both physical and biological aspects of their habitat. To refine these hypotheses a study area was designated in the vicinity of Elephant, Clarence, and King George Islands, and a field camp was established at Seal Island, a small island off the northwest coast of Elephant Island. From 1989-1996, shipboard studies were conducted in the study area to describe variations within and between seasons in the distributions of nekton, zooplankton, phytoplankton, and water zones. Complementary reproductive and foraging studies on breeding pinnipeds and seabirds were also accomplished at Seal Island.

Beginning in the 1996/97 season, the AMLR study area was expanded to include a large area around the South Shetland Islands, and a new field camp was established at Cape Shirreff, Livingston Island (Figure 1). Research at Seal Island was discontinued due to landslide hazards. Shipboard surveys of the pelagic ecosystem in the expanded study area are accomplished each season, as are land-based studies on the reproductive success and feeding ecology of pinnipeds and seabirds at Cape Shirreff.

The region-wide survey designs (Legs I and II, Surveys A and D respectively) in the vicinity of Elephant, Clarence, King George and Livingston Islands are described in Figure 2. Stations located to the west of Livingston and King George Islands are designated the "West Area", those to the south of King George Island are designated the "South Area", those around Elephant Island are designated the "Elephant Island Area", and those south of Elephant Island are designated the "Joinville Island Area". The survey grid was expanded this year to include stations in the Joinville Island Area in order to understand the dynamics and influences of the Weddell Sea on the AMLR survey area.

This is the 14<sup>th</sup> issue in the series of AMLR field season reports.

## SUMMARY OF 2002 RESULTS

The Russian R/V *Yuzhmorgeologiya* was chartered to support the U.S. AMLR Program during the 2001/02 field season. Shipboard operations included: 1) two region-wide surveys of krill and oceanographic conditions in the vicinity of the South Shetland Islands; 2) calibration of acoustic instrumentation at the beginning and end of survey operations; 3) a fur seal pup census at selected sites throughout the South Shetland Islands (Leg I); 4) a joint Zodiac/ship inshore survey of krill and oceanographic conditions near Cape Shirreff (Leg II); 5) deploying a buoy instrumented with acoustical sensors and buoy-to-shore telemetry in the vicinity of Cape Shirreff (Leg II); 6) collecting multi-scattering total target strength measurements of live animals (Leg II); and 7) shore camp support. Land-based operations at Cape Shirreff included: 1) observations of chinstrap, gentoo and Adélie penguin breeding colony sizes, foraging locations and depths, diet composition, breeding chronology and success, and fledging weights; 2) instrumentation of adult penguins to determine winter-time migration routes and foraging areas; 3) observations of

fur seal pup production and growth rates, adult female attendance behavior, diet composition, foraging locations and depths, and metabolic rates; 4) collection of female fur seal milk samples for determination of fatty acid signatures; 5) collection of fur seal teeth for age determination and other demographic studies; 6) tagging of penguin chicks and fur seal pups for future demographic studies; and 7) establishment of a weather station for continuous recording of meteorological data.

An oceanic frontal zone was mapped along the north side of the South Shetland Islands, running parallel to the continental shelf break and separating Drakes Passage water to the north from Bransfield Strait water to the south. As Leg I progressed, the frontal zone was further offshore with a plume of transition water situated from the southwest to the northeast with an eddy extending from the middle to the northwest quadrant of the survey area. Overall, as in previous years, the southern part of the survey area is mainly Bransfield Strait water (Water Zone IV) with an intrusion of Weddell water (Water Zone V) from the southeast. The northeast axis through the center of the survey area is dominated by transition water (Water Zones II and III) meandering into the north. The northwestern area is influenced by Drake Passage water and the southern boundary of the Antarctic Circumpolar Current (ACC). Chlorophyll concentrations were the opposite this year as compared to last year; concentrations were higher in coastal stations last year and this year concentrations were higher in the pelagic stations of the survey area. Highest concentrations of chl-*a* this year were observed in the West Area off the shelf in the deeper water stations. The lowest chlorophyll concentrations were seen near the Weddell Sea. Highest densities of krill were mapped over and offshore of the northeast Elephant Island shelf. Mean and median krill abundance in the Elephant Island Area was slightly higher in January 2002 than in 2001. Larger sized krill (>32mm) were rare in the South and Joinville Island areas whereas juvenile krill constituted 88-93% of the catches in the southern part of the archipelago. Krill larvae were present in greatest concentration in the Elephant Island Area. Overall krill abundance was higher during Leg II compared to Leg I this year due to the patchier distributions of krill collected during Leg I. This year's survey indicates a prolonged, and fairly successful krill spawning season. The overall abundance and size maturity composition indicated; extremely good proportional recruitment of the 2000/01 year class, essential absence of recruits from the 1999/00 year class; and markedly reduced numbers of krill from the highly successful 1995/96 year class. Mean salp abundance was substantially larger during Leg II when compared to Leg I. The late season spurt of aggregate salp production in 2002 is similar of the 1997 season, which preceded a major salp year in 1998. Copepods dominated the zooplankton assemblage. This, and other aspects of the zooplankton assemblage, suggested that 2000 and 2001 may be classified as transition years between a salp-dominated community and a copepod-dominated community. Additionally with the expanded survey grid this year came the introduction of higher latitude zooplankton taxa, which previously had not been encountered. This was especially true for the Joinville Island Area, influenced by the Weddell Sea and the South Area adjacent to, and influenced by, outflow from the Gerlache Strait.

The inshore survey near Cape Shirreff (Figure 3) was accomplished using a 5-m Zodiac configured with a 120kHz echo sounder, an underwater video camera, a CTD, several continuously recording sea surface and meteorological sensors, two GPS receivers, a radar, and emergency equipment. The Zodiac was used to map krill within 15 nautical miles of the Cape while the ship surveyed further offshore. The survey was staged from the field camp and

conducted over a 7-day period. Substantial amounts of krill were mapped inshore of the region surveyed by the ship and the feasibility of using a small boat to conduct inshore surveys in Antarctica was demonstrated.

The 2001/02 population counts at Cape Shirreff represents the lowest chinstrap penguin count on record. The gentoo penguin population was down considerably from last year, but was within the five-year averages. Mean chinstrap penguin clutch initiation dates coincided exactly with dates from the past two seasons; however, gentoo penguins laid eggs a mean ten days early than previous seasons. Chinstrap penguin reproductive success in 2001/02 was the lowest on record for Cape Shirreff, while gentoo penguin reproductive success was within the five-year averages. This season represented a 23.7% decline for chinstrap penguins and an 18.3% decline for gentoo penguin chicks, compared to the 2000/01 counts. This season we had a significant increase in the number of known-age chinstrap and gentoo penguins breeding. These birds were banded as chicks at Cape Shirreff and have returned to their natal colonies to breed. The dominant prey species in the diet samples was krill, which were found in 100% of samples from both chinstrap and gentoo penguins. Analysis of length-frequency distribution of krill in the penguins' diets revealed a wide range of krill size classes from 18mm to 63mm. Chinstrap penguin diets were composed almost entirely of krill with only 15% of samples containing otoliths or trace amounts of fish. Gentoo penguins consumed more fish with 70% of the diet samples containing some portion of fish in addition to krill. Results of satellite tagged birds revealed that the birds were foraging farther offshore than in the previous season, a pattern likely to account for the longer trip lengths we found in 2001/02. This season birds traveled up to 30km offshore to feed at the shelf break in January 2002. This represents a very different foraging pattern from data gathered during the 2000/01 January period, when all penguin foraging activity was confined to the shelf area within 10km of the colony.

The 2001/02 season was better for Antarctic fur seals by several measures than the 1997/98-1999/00 seasons. It was similar in some respects to last year but mean foraging trip duration for lactating females was slightly longer than in 2000/01. Fur seal pup production at U.S.-AMLR study beaches on Cape Shirreff increased by 8.3% over last year. The median date of pupping based on pup counts was one day earlier than the last two years and three days earlier than in 1997/98 and 1998/99. The mean trip duration for adult females' first 6 trips to sea was slightly greater than last year (3.18 vs. 2.71 days) but still less than from 1997/98 to 1999/00 (4.19, 4.65, and 3.47 days, respectively). Fur seals this year had slightly more fish in their diet than in previous years. The mean length of krill in fur seal diet decreased this year over last year, reflecting the same results as found in net tows from the oceanographic survey.

A fur seal survey was conducted at 13 sites throughout the South Shetland Islands (Figure 4). Discovered in 1819, the South Shetland Islands soon became the focus of intensive sealing efforts. Abundant, but never quantified, Antarctic fur seal populations were exterminated by 1874 and did not begin re-colonizing until approximately 80 years later. The first reported pups born post-exploitation were found at Cape Shirreff, Livingston Island in January 1960. In 1987, an archipelago-wide aerial and ground census identified breeding colonies and substantial increases in pup production. A ground survey of all known fur seal colonies from Smith to Elephant Islands was conducted from 30 January –5 February 2002. Multiple counts of pups at each colony were conducted to establish confidence limits on pup production. Total pup

production was 10,057 ( $\pm 142$ ); 85% were from Cape Shirreff (64%) and San Telmo Islands (21%). Dead pups accounted for 1.37% of the total. A comparison with previous censuses over a 15-year period (1987, 1992, 1994, and 1996) indicates the rate of increase in fur seal populations has diminished substantially. The averaged annual rate of increase from 1987-1994 was between 13.5-13.9%. From 1994-1996 it was 8.5% and from 1996-2002 the average annual rate was +0.9%. Pup production at individual colonies varied with some increasing and others decreasing. The San Telmo Islands had the largest decline from 2,684 pups in 1996 to 2,124 in 2002 (-3.5%/yr). Pup production at Cape Shirreff increased from 4,968 to 6,453 pups (5.0%/yr) during the same period. Cape Lindsey, Elephant Island, and the Seal Islands had averaged annual declines of -9.4 and -6.3% from 1996-2002.

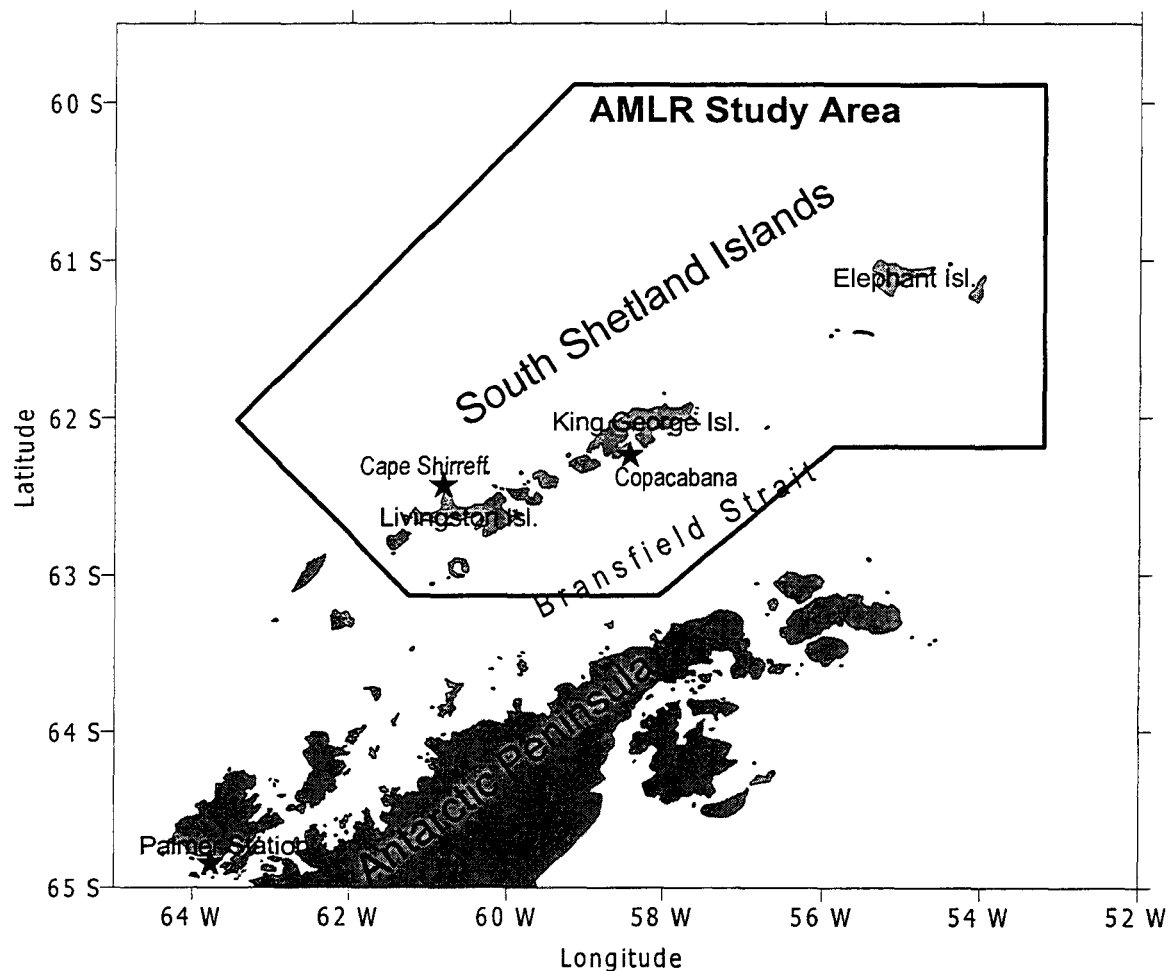


Figure 1. Locations of the U.S. AMLR field research program: AMLR study area, Cape Shirreff, Livingston Island and Copacabana, King George Island.

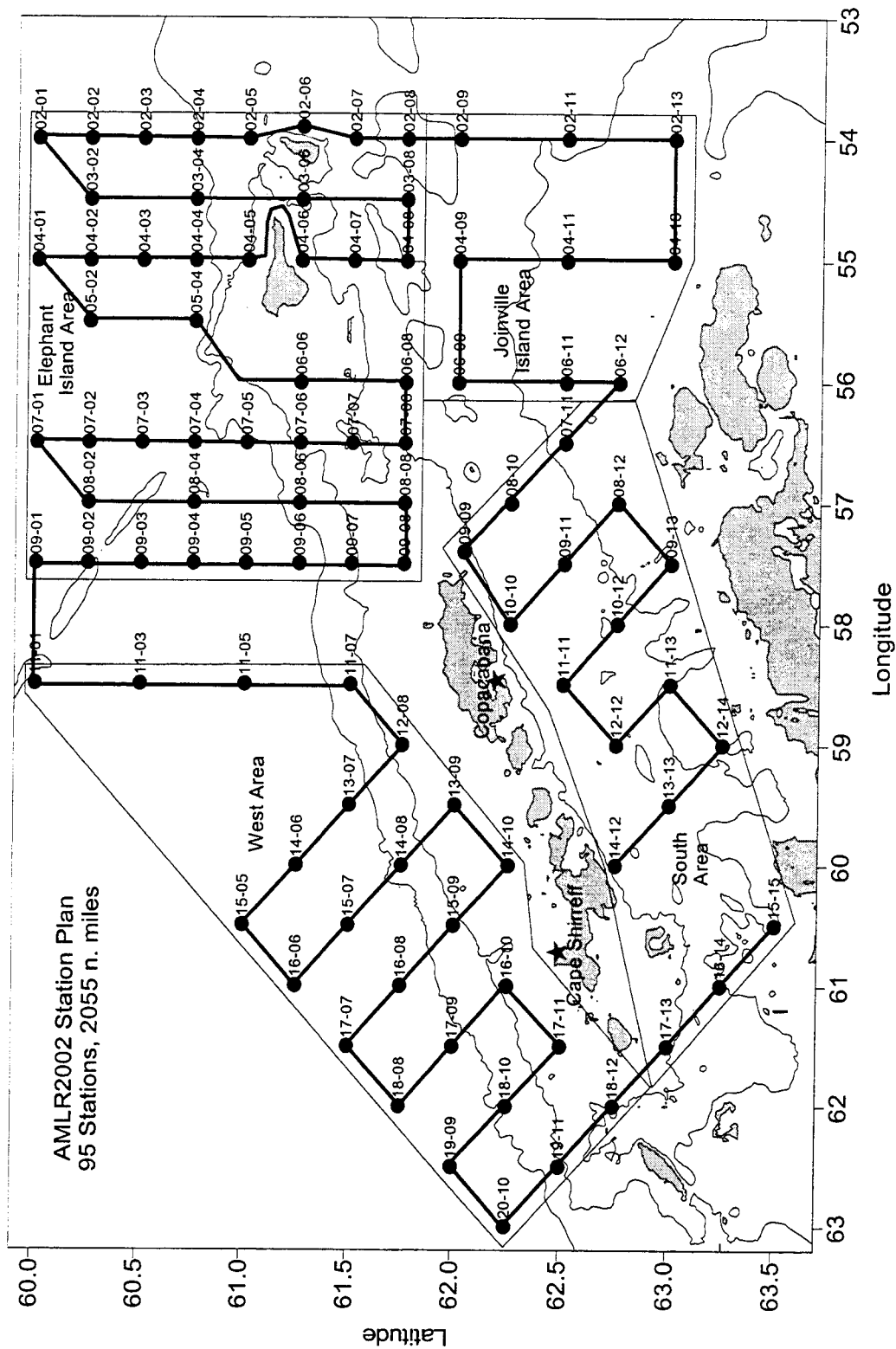


Figure 2. The large-area survey for AMLR 2002 (Survey A & D) in the vicinity of Elephant, Clarence, King George and Livingston Islands. Stations located to the west of Livingston and King George Islands are designated the "West Area", those to the south of King George Island are designated the "South Area", those around Elephant Island are designated the "Elephant Island Area", and those south of Elephant Island are designated the "Joinsville Island Area". Longitude is West and latitude is South.

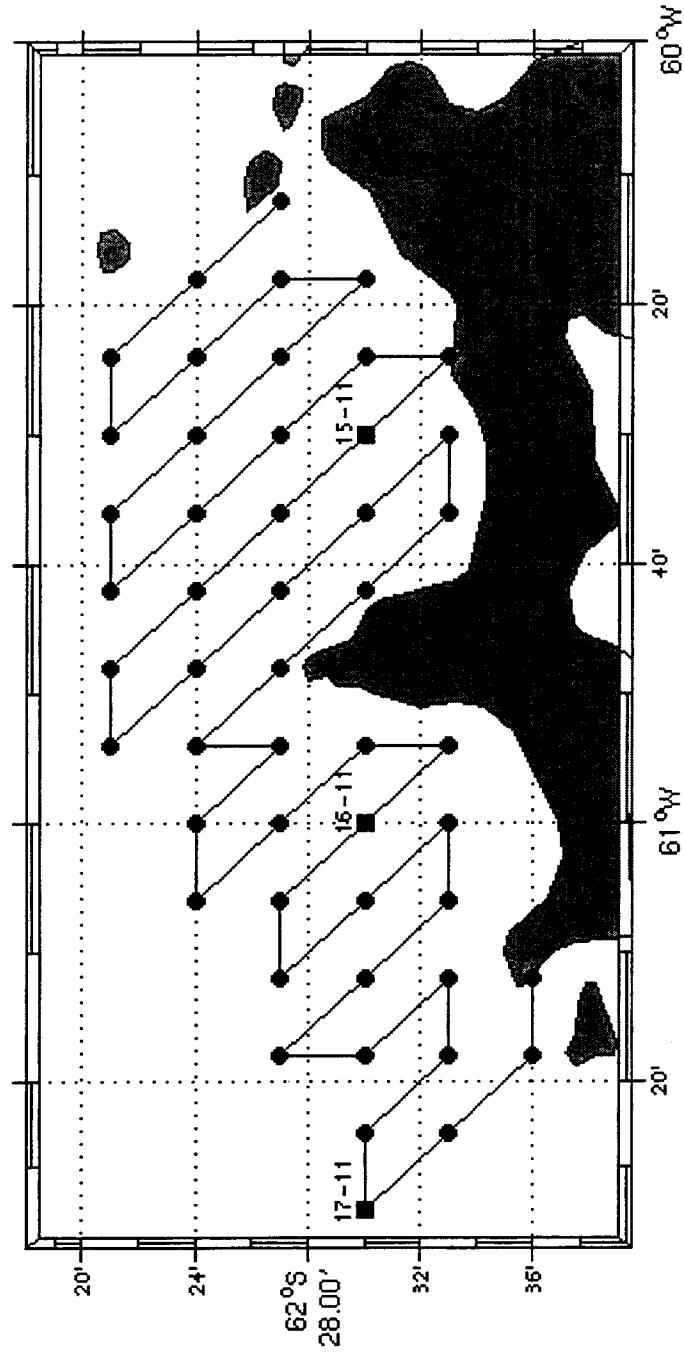


Figure 3. Cape Shirreff Survey, R/V *Ernest* transects and stations.

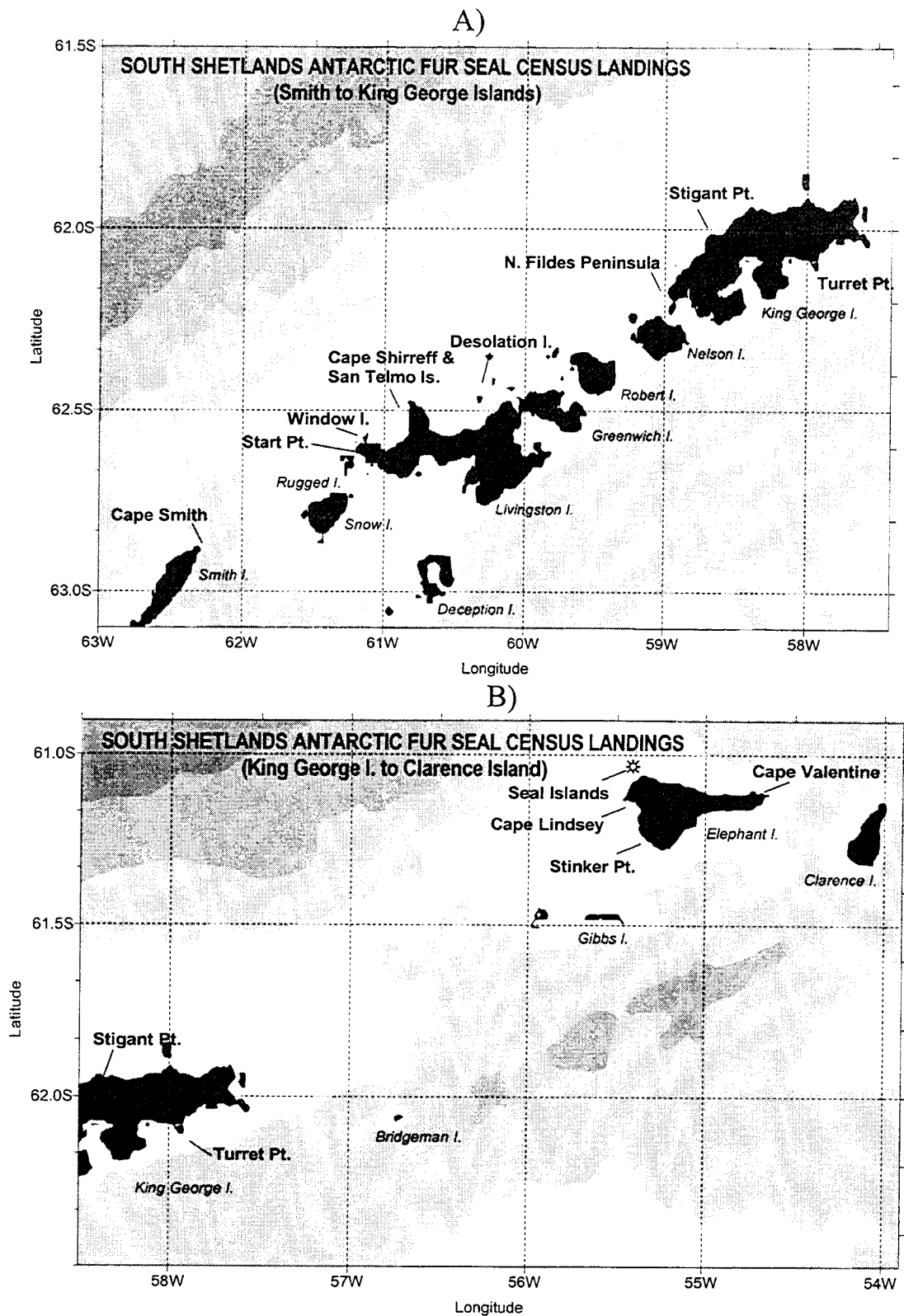


Figure 4. Known fur seal breeding colonies ( $n=13$ ) in the South Shetland Islands, A) Smith Island to King George Island, and B) King George Island to Elephant Island.